Elective Stent-graft Treatment for the Management of Thoracic Aorta Mural Thrombus

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WHAT THIS PAPER ADDS

The present study describes experience of thrombus management with stentgraft. This technique can reduce mortality and morbidity associated with conventional surgery. The impact of morphological criteria on the choice of suitable patients for intervention is analyzed.

Background: Optimal management of aorta mural thrombus (AMT) continues to be controversial. The aim of this study was to describe the management of AMT in the thoracic aorta with either conservative or stentgraft treatment and to analyze the role of morphological characteristics of thrombus in the selection of suitable candidates for intervention.

Methods: A retrospective review was conducted of all patients admitted for thoracic AMT. Clinical data, treatment used, and outcomes were recorded. Patients were divided in two groups according to the treatment used: either conservative or stentgraft. Morphological features of thrombus, including size, sessile or pedunculated aspect and mobility, were compared between the two groups.

Results: From January 2006 to March 2013, 13 consecutive patients (nine male, mean age 53, range 37–76) were admitted for symptomatic ($n = 8$) or asymptomatic AMT ($n = 5$). All patients received unfractionated heparin. Management of primary aortic thrombus required stentgraft in seven patients, aortic thrombectomy in one, and anticoagulation therapy alone in five. Indications for intervention were recurrent embolism ($n = 4$), occurrence of embolism under heparin ($n = 1$), or persistent thrombus ($n = 2$). Endovascular exclusion of AMT was successful in all cases, with no complications or deaths at 30 days and no recurrence at midterm. Analysis of the morphological features of the thrombus identified solely the high degree mobility as associated with adverse outcome ($p = .048$).

Conclusion: In our experience, stentgraft exclusion of AMT is an effective approach. Systematic evaluation of thrombus mobility by a real-time imaging study can be helpful to better define the indications for radical treatment of the aortic lesion.

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INTRODUCTION

The aortic wall is recognized as a potential cause of systemic emboli.[1,2] These embolic syndromes from the aorta include diverse entities varying from thrombi in apparently normal aortas to those found in complicated atherosclerotic plaques.[3] Until now, reports in the literature have mainly mentioned aortic thrombi associated with diffuse atherosclerosis, which are well-known as protruding atheroma or aortic debris.[4–6] Aortic mural thrombus (AMT) or primary aortic thrombus characterized by sessile or pedunculated aortic thrombi that develop in the absence of pre-existing aortic disease is a less well-described entity. The natural history, prognosis, and management of AMT remain unclear and no long-term follow-up is available. Therapeutic methods differ between those in favour of medical treatment with systemic anticoagulation,[7–9] and those in favour of an open surgical option.[10,11] More recently, a few published case reports[12–22] have advocated endovascular management with stentgraft exclusion as a safe and minimally invasive option compared with open procedures. This raises questions concerning the indications for primary aortic lesion treatment.

In order to select candidates for primary aortic surgery, certain factors have been identified in the literature as predictors of adverse outcome.[23] The part played by thrombus morphology in the choice between conservative and surgical management is controversial. However, no studies analyzed clearly the criteria related to the degree of thrombus mobility.

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The present study reports our experience of thoracic AMT management either with solely anticoagulation therapy or stentgraft deployment and analyzes the role of morphological characteristics of the thrombus in the decision for primary aortic lesion treatment.

MATERIALS AND METHODS

From January 2006 to March 2013, we retrospectively reviewed all patients who were admitted to our department with thoracic aortic mural thrombi. The diagnosis was determined by the clinical contexts of embolic events and imaging criteria.

A thoraco-abdominal computed tomography angiography (CTA) was systematically performed as part of the etiological diagnosis of arterial embolism and therefore represented the first imaging modality revealing the AMT. Transoesophageal echocardiography (TEE) was indicated in cases of persistent thrombus, defined as a stable thrombus after more than 15 days of anticoagulation, or recurrent embolism. It was used as a complementary method to evaluate the floating aspect of the aortic lesion which was classified as highly or minorly mobile, thus helping to define therapeutic strategies.

Highly mobile thrombus was defined as a thrombus with free edge moving on either side of an axis perpendicular to the implantation site during the cardiac cycle visualized in the two-dimensional view, and in an oscillatory fashion in the M-mode. For the other cases the thrombus was considered as minorly mobile. Patients with aortic thrombus associated with underlying aortic disease (diffuse atherosclerotic disease including protruding atheroma, penetrating aortic ulcer or aneurysm) as well as aortic mural tumour were excluded.

Medical records of patients were reviewed for: demographic data, medical co-morbidities, symptoms on admission, imaging studies, morphological characteristics of thrombus including size, pedunculated or sessile aspect and mobility, outcomes after anticoagulation therapy, indications for stentgrafts, procedural details and ultimate outcomes after medical or endovascular treatment.

In our practice, all patients admitted with the diagnosis of AMT received initial unfractionated heparin for 2 weeks. The distal embolic events were managed with embolectomy, except for renal embolism associated with parenchyma infarction which was conservatively treated with heparin.

Indication for primary aortic lesion treatment

Stentgraft treatment was reserved for patients with failed anticoagulation therapy: firstly for occurrence of embolic event in initially asymptomatic patients on heparin; secondly for recurrence of an embolization episode in a symptomatic patient despite full anticoagulation; and thirdly for persistent thrombus despite more than 15 days of medical treatment with high degree of mobility on TEE.

Patients who were considered as high risk for aortic surgery and those with regressive thrombus, whether symptomatic or asymptomatic, were given only anticoagulation therapy.

Stentgraft procedure

The procedures were performed in the operating theatre under general anaesthesia. A femoral or iliac access was used to introduce the aortic stentgraft. Left brachial access was generally used for the contrast injection, to avoid crossing the mobile thrombus. Manipulation of the guidewire in the thoracic aorta was limited. Thoracic aortic stentgrafts were used to completely exclude the thrombus. The choice of device in terms of length and diameter was made by an oversizing of less than 10% of the measured luminal diameter and the length of the aortic thrombus plus 2 cm above and below the implantation site of thrombus.

TEE was used intra-operatively to ensure safe advancement and positioning of the stentgraft. Remodelling was not used after the deployment of the stentgraft. If the proximal landing zone of the stentgraft was located proximal to the left subclavian artery, a preliminary debranching of the supra-aortic vessels was performed.

Follow-up

After discharge, the follow-up protocol comprised regular consultations at 6 and 12 months and then yearly, with a duplex scan of the peripheral and/or visceral arteries and aortic CTA. Outcomes, including recurrent embolism or aortic thrombus and death, were recorded.

Statistical analysis

Non-parametric Mann—Whitney test was performed to compare the mean size of thrombus between the stentgraft and conservative group, whereas the Fischer exacts tests were used to compare frequencies. A p value below 0.05 was considered significant.

RESULTS

During the study period, 13 patients were admitted for AMT of thoracic aorta (nine male, mean age 53 years, range 37—76 years).

Clinical presentation and etiological factors

At the time of admission eight patients were symptomatic with arterial embolism, involving lower extremity in four, upper extremity in one, superior mesenteric artery in one, vertebral artery in one, and in the remaining patient multiple emboli (lower extremity, superior mesenteric artery and renal artery). For the other five patients the aortic thrombus was revealed fortuitously in staging CTA for severe asthma in one, trauma in one, ischemic stroke related to carotid stenosis in one, and pulmonary neoplasm in two.

Predisposing factors to thrombus formation included: thrombophilia $n = 2$ (protein S deficiency in one case and hyperhomocysteinaemia in the other), inflammatory bowel disease $n = 1$, trauma $n = 1$, steroid therapy $n = 1$,

malignancy $n = 3$. There were eight patients (62%) with one or several cardiovascular risk factors (Table 1).

Treatment

All patients, whether symptomatic or asymptomatic, were given anticoagulation therapy with unfractionated heparin for at least 15 days. Four patients had recurrence of embolization (peripheral emboli in two cases, cerebral emboli in one, and mesenteric emboli in one) and one had a new embolic event despite full anticoagulation (Table 2).

Management of the arterial embolism required surgical embolectomy in six patients. Patient no. 11, initially admitted for acute limb ischemia, was contraindicated for surgical treatment, and therefore treated conservatively. Histological examination of the thrombus revealed a fibrinous clot in all cases.

Management of the primary aortic thrombus required stentgraft deployment in seven patients and a transaortic thrombectomy of the thoracic aorta and the visceral arteries in one patient, for whom the lesion was anatomically unfavourable for endovascular treatment (Table 2).

Indications for aortic lesion treatment were the recurrence of the embolic event in four, the occurrence of renal embolism despite full anticoagulation in one, and the persistence of a highly mobile thrombus after more than 2 weeks of systemic anticoagulation in two. For the other five patients the primary aortic thrombus was medically treated with warfarin for 6 months (Table 2). The choice of conservative treatment was based on the low degree of mobility for the initially persistent thrombus ($n = 2$) and the favourable outcome after systemic anticoagulation with either regression of the mobile part ($n = 2$) or complete resolution of the thrombus ($n = 1$).

For the endovascular group, emergency procedures were performed within 24 hours of diagnosis in instances of recurrence or occurrence of embolism. Intra-operative TEE was used in four patients. The stentgrafts deployed were Zenith TX2 (William Cook Europe, Bjaeverskov Denmark) ($n = 5$) and Valiant Captivia (Medtronic Vascular, Santa Rosa, CA, USA) ($n = 2$). Only one endoprosthesis of 100 to 115 mm length was used per patient. For two patients with thrombus in the distal arch, transposition of the left subclavian artery was required prior to the exclusion of the aortic lesion. No patient had spinal catheter drainage during the procedure. No intra- or postoperative complications occurred and no death was noted at 30 days. All the patients were discharged with single antiplatelet therapy (aspirin or clopidogrel) except the patient with trauma, who had a vena cava thrombus, and the two patients with thrombophilia, who were switched to warfarin.

Analysis of thrombus characteristics

CTA revealed a sessile thrombus in four cases in the stentgraft group and three cases in the conservative group (Fig. 1A, B). The thrombus was located in the aortic arch in three patients, in the descending thoracic aorta in six, and in the thoraco-abdominal aorta in four with an extension to the visceral arteries in one (Fig. 2). The mean length of aortic thrombus was 29 mm (range 15–80 mm) in the stentgraft group and 26 mm (12–35 mm) in the conservative group. A complementary TEE was performed preoperatively in six cases revealing a highly mobile thrombus in four and a minorly mobile thrombus (Table 2).

Analysis of the different criteria showed a significantly higher rate of highly mobile thrombus in the stentgraft group compared with the conservative group ($p = .048$). Thus, high mobility can be considered as a factor associated with anticoagulation therapy failure. However, the size was similar in the two groups ($p = .37$) as were the sessile or pedunculated aspects of thrombus ($p = 1$).

Clinical and CTA follow-up

After a mean follow-up of 32 months (range 2–78 months) for the patients treated with stentgraft, control findings showed satisfactory outcomes, with neither AMT recurrence nor re-embolization (Table 2; Fig. 1C).

For the medical treatment group, the mean follow-up was 15 months (range 5–25 months). Outcomes were favourable, except for the patient with gastric cancer who died at 25 months secondary to neoplasm (Table 2).

Table 1. Demographic data of the study population.

Patient no.	Age (y)	Gender	Predisposing factors	Cardiovascular risk factors
1	61	F	–	DM, HT
2	65	M	–	HT
3	51	M	–	Smoking
4	53	M	–	DM
5	38	M	Thoracic trauma	–
6	37	F	–	Smoking
7	38	F	Protein S deficiency	Smoking
8	76	M	Steroid therapy	–
9	53	M	Gastric malignancy	–
10	55	M	Hyperhomocysteinaemia	–
11	45	M	Crohn's	–
12	75	M	–	HT
13	43	F	Pulmonary cancer	Smoking

DM = diabetes mellitus; HT = hypertension; y = years.

Table 2. Clinical data, treatment, and outcomes of the study population.

Patient no.	Site of embolization	Size (mm)	Morphological features	TEE	Primary therapy	Outcome of primary therapy	Treatment of aortic lesion	Results	Follow-up (months)
1	Brachial	20 × 15	Sessile	High mobile	Embolectomy	Recurrence	Stentgraft	No recurrence	78
2	VA	15 × 15	Sessile	None	Anticoagulation	Recurrence	Stentgraft	No recurrence	22
3	Bilateral CFA, SMA, RA	80 × 20	Sessile	None	Femoral embolectomy	Persistent thrombus	Transthoracic open thrombectomy	No recurrence	52
4	CFA	25 × 10	Pedunculated	High mobile	Femoral embolectomy	Persistent thrombus	Stentgraft	No recurrence	48
5	None	30 × 10	Pedunculated	None	Anticoagulation	Renal embolism	Stentgraft	No recurrence	18
6	SMA	17 × 8	Pedunculated	High mobile	Embolectomy	Recurrence	Stentgraft	No recurrence	2
7	PA	22 × 20	Pedunculated	None	Embolectomy	Recurrence	Stentgraft	No recurrence	28
8	None	25 × 8	Sessile	High mobile	Anticoagulation	Persistent	Stentgraft	No recurrence	32
9	FP	35 × 8	Pedunculated	None	Embolectomy	Recurrence	Conservative	Thrombus resolution	25
10	None	20 × 18	Sessile	Low mobile	Anticoagulation	No embolism	Conservative	Thrombus regression	24
11	FP	35 × 20	Sessile	None	Anticoagulation	No recurrence	Conservative	Thrombus resolution	12
12	None	28 × 12	Pedunculated	Low mobile	Anticoagulation	No embolism	Conservative	Thrombus regression	6
13	None	12 × 20	Sessile	None	Anticoagulation	No embolism	Conservative	Thrombus regression	5

TEE = transoesophageal echocardiography; VA = vertebral artery; CFA = common femoral artery; SMA = superior mesenteric artery; RA = renal artery; PA = popliteal artery; FP = femoropopliteal.

DISCUSSION

Emboli from apparently normal aortas are rare events. The pathophysiological mechanisms of locally formed thrombi in the aortic wall remain poorly defined. Hypercoagulability and primary endothelial disease have been proposed as the most important aetiological factors for AMT formation.[7] In our study, thrombophilia factors were found in two patients; however, 62% of patients had cardiovascular risk factors, as in Reber's series,[24] suggesting that AMT formation is primarily a localized problem of vulnerable aortic wall lesions which are a focal point for local thromboses. Moreover, in practice it is difficult to exclude atherosclerosis as the aetiology of these lesions. AMT can thus be considered as a variant of atherosclerosis, occurring in young patients and characterized by pure and local clot formation, even if no atherosclerotic plaques is found on the imaging studies. This hypothesis is also supported by Laperche et al.[25] in a TEE analysis of patients with aortic arch mobile thrombus showing a small atherosclerotic plaque less than 4 mm at the insertion site of thrombus in 64% of cases and a normal adjacent aortic wall in 74% of cases.

Different therapeutic options have been suggested for the management of such lesions, including medical treatment with anticoagulation therapy, surgical treatment, thrombolysis, and, more recently, endovascular exclusion with a stentgraft, but no clear consensus has been adopted. Nevertheless, given the high risks of recurrence or persistence of thrombus on the one hand, and on the other hand a tendency to a high rate of complications and limb loss associated with medical treatment noted in the meta-analysis of Fayad et al.,[23] surgical management of AMT appear to be favoured.

Indeed, the rate of recurrence after heparin treatment is 33% in the series of Rossi et al.,[11] 25.7% in the meta-analysis of Fayad et al.,[23] and in our series 39% ($n = 5$) of patients presented with either a recurrence of the embolization or a new embolic event.

Considering the high perioperative mortality and morbidity related to conventional surgery, Fayad et al.[23] failed to show a significant difference between the anticoagulation group and the primary aortic surgery group. However, with a less invasive technique such as stentgraft treatment, it may be possible to demonstrate the benefit.

In our study primary aortic thrombus was managed according to criteria related to the patient's co-morbidities and to the lesions - outcomes after anticoagulation therapy and mobility on TEE. Endovascular treatment remains our preferred approach. Surgical transaortic thrombectomy is reserved for instances of unfavourable stentgraft anatomy.

Since the first description of stentgraft use by Criado et al.,[12] few other case reports of endovascular exclusion of mobile thoracic thrombi have been published. So far, our analysis of the literature has identified 10 cases of stentgraft implantation for AMT exclusion.[12–22] In eight cases, the thrombus was located in the distal arch or the descending thoracic aorta. For the remaining two patients

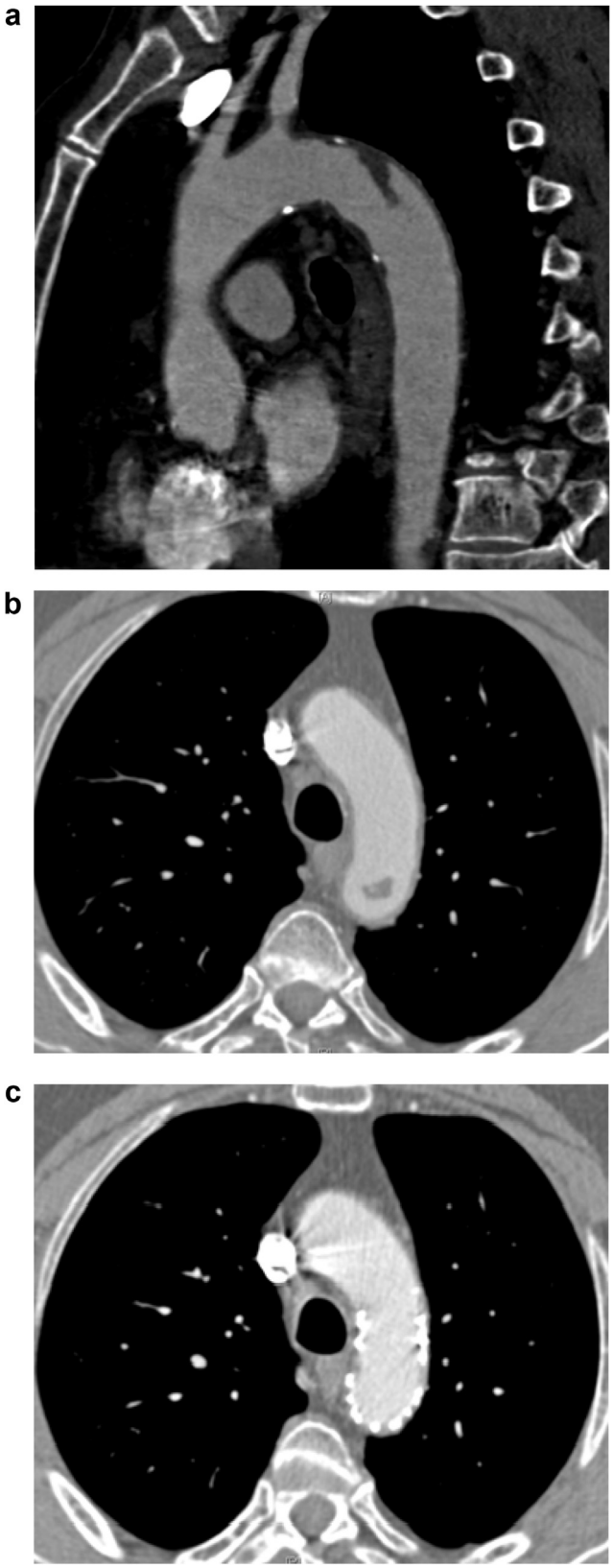

Figure 1. A 76 year-old-patient with asymptomatic thrombus in the aortic isthmus. (A) Sagittal view of CT scan shows a sessile thrombus originating 2 cm below the left subclavian artery. (B) Axial view shows the floating aspect of the thrombus. (C) Axial view of the post-operative CT scan shows no recurrence 32 months after stentgraft implantation.

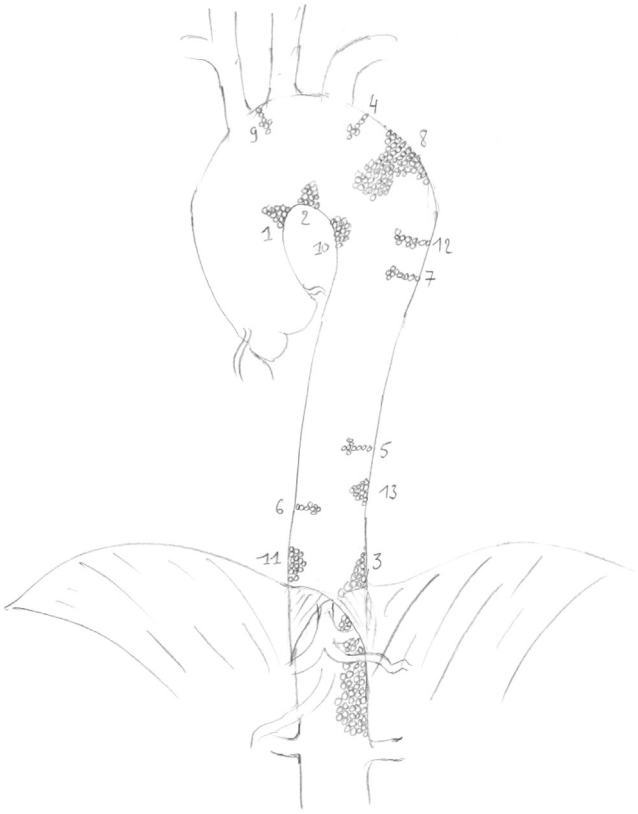

Figure 2. Schematic representation of thrombus location and aspect in the different segments of the thoracic aorta.

in whom the thrombus was located in the aortic arch, the treatment consisted of a hybrid technique for one and the VORTEC technique for the other.[19,21] All these cases were successfully treated with no deaths or major complications.

The main concern with this technique is the risk of thrombus dislodgment either during navigation of the aorta by the guide-wire and/or the stentgraft deployment. In our series, several measures were adopted to prevent the risk of distal embolization. Firstly, the procedure was performed without interrupting systemic anticoagulation. Secondly, manipulation of wires and catheters in the aorta were minimized. Thirdly, an appropriate stentgraft was chosen in terms of diameter (oversizing $<10\%$) and length making it possible to cover the aorta at least 2 cm above and below the implantation site of the thrombus.

Data from the literature and in our series showed no arterial embolism during the procedures. However, as recommended by Fueglistaler et al.,[17] we systematically performed visceral angiography at the end of the procedure to detect any potential embolization.

In the aforementioned meta-analysis,[23] the authors identified predictive factors for the recurrence of embolic event in order to select suitable surgical candidates. These factors were related to clinical presentation (stroke), location of thrombus (ascending aorta or aortic arch), and atherosclerotic status of the aortic wall (mild atherosclerosis).

The characteristics of the thrombus in terms of mobility have been identified by others[25–27] as a determining factor

for primary surgical treatment. However, in these reports the mobility was not clearly defined. In our study TEE was used as an imaging modality to provide dynamic visualization of thrombus which was classified as highly or minorly mobile. Analysis of TEE findings showed that highly mobile thrombus was significantly associated with adverse outcome. However, as in the meta-analysis of Fayad et al.,[23] the size and the pedunculated or sessile nature of the thrombus were similar in both groups.

With the advent of the endovascular approach, the indication for treating aortic wall thrombotic lesions should also be reconsidered, given the high risk of embolism with these lesions on the one hand, and the less invasive nature of the procedure on the other. We fully acknowledge that final conclusions cannot be drawn from the small number of patients in our series. However, in our experience, excluding thoracic aortic thrombi with stentgraft does appear to be an efficient approach with minimal risk of peri-operative emboli or recurrence of the thrombi. TEE was useful in deciding between the conservative and the endovascular options. However, this technique is limited by the poor visualization of the junction between the ascending aorta and the aortic arch as a result of interposition of the trachea.

We believe that systematic evaluation of thrombus mobility provided by a real-time dynamic imaging, notably TEE, is necessary to identify patients with high risk of embolism. Such patients can be considered as good candidates for early endovascular treatment given the potential failure risk of a purely conservative approach.

CONCLUSION

AMT is a rare event with serious potential consequences. Management of the primary aortic lesion with anticoagulation therapy alone poses a risk of recurrence or occurrence of an embolic event. In our experience, stentgraft exclusion seems to be a safe approach. Systematic evaluation of thrombus mobility by real-time imaging studies can be useful to select patients at risk of embolism and to better define indications for radical treatment of the aortic lesion.

CONFLICT OF INTEREST

None.

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